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Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
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Report on the implementation of the decisions adopted by the Conference of the Parties at its sixth meeting

Technical guidelines for environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls, polychlorinated terphenyls or polybrominated biphenyls

* UNEP/CHW.7/1.

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Abbreviations and acronyms

ABS	acrylonitrile butadiene styrene
BAT	best available technique(s)
BCD	base-catalysed decomposition
BEP	best environmental practice(s)
DE	destruction efficiency
DRE	destruction removal efficiency
ESM	environmentally sound management
GC	gas chromatography
GPCR	gas phase chemical reduction
HASP	health and safety plan
HCB	hexachlorobenzene
MS	mass spectrometry
PACT	plasma arc centrifugal treatment
PBB	polybrominated biphenyl
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PCN	polychlorinated naphthalene
PCT	polychlorinated terphenyl
POP	persistent organic pollutant
PWC	plasma waste converter
SCWO	supercritical water oxidation
TEQ	toxic equivalent

Units of measurement

gal	gallon
l	litre
kg	kilogram
mg	milligram
ng	nanogram
µm	micrometre
Nm^3	normal cubic metre: gas volume measured at 0°C and 1 atm (atmosphere of pressure)
Rm^3	reference cubic metre: gas volume measured at 25°C and 1 atm
kPa	kilopascal
kW	kilowatt
kWh	kilowatt-hours
MJ	megajoule
million	10^6
billion	10^9
trillion	10^{12}
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion

I. Introduction

A. Scope

1. This document supersedes the Basel Convention's technical guidelines on wastes comprising or containing PCB, PCT and PBB (Y10) (February 1997).

2. These technical guidelines provide guidance for the environmentally sound management (ESM) of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs) in accordance with decisions V/8, VI/23 and VII/[ ] of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, decisions OEWG-I/4, OEWG-II/10 and OEWG-III/8 of the Open-ended Working Group of the Basel Convention, and taking into account decisions INC-6/5 and INC-7/6 of the Intergovernmental Negotiating Committee for an International Legally Binding Instrument for Persistent Organic Pollutants. The Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants will consider these guidelines in accordance with article 6.2 of that convention.

3. Along with PCBs, these technical guidelines address polychlorinated terphenyls (PCTs) and polybrominated biphenyls (PBBs) as a class or category of substances owing to similarities in the physico-chemical and toxicological properties of these substances. Topics addressed include waste management, treatment and disposal. It should be noted that neither PCTs nor PBBs are subject to the Stockholm Convention.

4. Unintentionally produced PCBs are not covered by these technical guidelines. They will be addressed in technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs).

5. This document should be used in conjunction with the *General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants (General Technical Guidelines)*. This document provides more detailed information on the nature and occurrence of wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs for purposes of their identification and management.

B. Description, production, use and wastes

1. Description

(a) PCBs

6. PCBs are aromatic compounds formed in such a manner that the hydrogen atoms on the biphenyl molecule (two benzene rings bonded together by a single carbon-carbon bond) may be replaced by up to ten chlorine atoms. In theory there are 209 congeners, although only about 130 congeners have actually been found in commercial chemical formulations (Holoubek 2000). Typically, four to six of the ten possible substitution sites are occupied by a chlorine atom (Environment Canada 1988). The more highly chlorinated PCB congeners are virtually insoluble in water and highly resistant to degradation.

7. PCBs include 12 congeners for which the World Health Organization has assigned toxicity equivalency factors because they exhibit dioxin-like toxicity (coplanar PCBs).

(b) PCTs

8. PCTs also constitute a group of halogenated hydrocarbons. They are very similar in chemical structure to PCBs, except that they contain three phenyl rings instead of two. Therefore, they can have up to 14 chlorine atoms attached. The number of possible PCT congeners is very large; however, only a few occur in commercial chemical formulations. PCTs and PCBs have very similar chemical and physical properties. PCTs are virtually insoluble in water and highly resistant to degradation. One difference between PCTs and PCBs is that PCTs are generally less volatile.

(c) PBBs

9. PBBs are the bromine analogues of PCBs and thus have 209 possible congeners. Only a few, however, occur in commercial chemical formulations (International Programme on Chemical Safety (IPCS), 1994). They are solids or waxy substances at room temperature. They are virtually insoluble in water and highly resistant to degradation.

2. Production

(a) PCBs

10. PCBs have excellent dielectric properties, longevity, non-flammability and resistance to thermal and chemical degradation. For this reason, prior to national bans, they were manufactured for use in electrical equipment, heat exchangers, hydraulic systems and several other specialized applications.

11. The main period of manufacture occurred from 1930 to the late 1970s in the United States of America; up to 1974 in China (China State Environmental Protection Agency 2002); up to the early 1980s in Europe, up to 1993 in Russia (AMAP 2000); and from 1954 to 1972 in Japan.

12. PCBs were manufactured as mixtures of congeners, for example as progressive chlorination of batches of biphenyl until a certain target percentage of chlorine by weight was achieved. The manufactured PCBs were rarely used at full strength. For example, they were added in small quantities to ink, plastics, paints and carbon paper or were used in formulations of up to 70% PCBs in hydraulic fluid, transformer fluid and heating fluids. At room temperature, the majority of them are oily liquids or waxy solids.

13. Prominent trade names of PCB products include those listed below. (See annex I for a more detailed list of PCB trade names and synonyms and section IV.D of the present report for considerations regarding precautions to take when using trade names in inventory exercises.)

Apirolio (Italy)
Aroclor (United States)
Clophen (Germany)
Delor (Czechoslovakia)
Elaol (Germany)
Fenchlor (Italy)
Kanechlor (Japan)
Phenoclor (France)
Pyralene (France)
Pyranol (United States)
Pyroclor (United States)
Santotherm (Japan)
Sovol (USSR)
Sovtol (USSR)

14. In the Aroclor series, a four-digit number follows the word Aroclor. The first two digits of the number are either 10 or 12. The number 12 indicates a normal Aroclor while the number 10 indicates a distillation product of an Aroclor. The second two digits of the four-digit code indicate the percentage of chlorine in the mixture by weight. Therefore, Aroclor 1254 contains approximately 54% chlorine by weight.

15. Commercial PCB products and articles were sold for their industrial properties rather than for their chemical composition (IPCS 1992). They contained a number of impurities and were often mixed with solvents, such as tri- and tetrachlorobenzenes. Those PCBs mixed with tri- and tetrachlorobenzenes were called askarel. Contaminants in commercial mixtures include polychlorinated dibenzofurans (PCDFs) and chlorinated naphthalenes. Studies have found from 0.8 milligrams per kilogram (mg/kg) to 40 mg/kg of PCDFs in commercial mixtures (IPCS 1992). PCBs are also formed unintentionally in some thermal and chemical processes.

16. The cumulative worldwide production of PCBs has been estimated at 0.75–2 million tons.

(b) PCTs

17. PCTs were manufactured in much smaller quantities than PCBs and were given the same or similar trade names. They were used for the same sorts of applications as PCBs, although most were used in waxes, plastics, hydraulic fluids, paints and lubricants (Jensen and Jørgensen 1983). In the United States, Aroclor series PCTs are indicated by the digits 54 in the first two spaces of the four-digit code, e.g. Aroclor 5432, 5442 and 5460 (IPCS 1992). See annex I for examples of trade names and section IV.D for a discussion of trade names in inventory identification.

18. Examples of trade names are Aroclor (United States) and Kanechlor KC-C (Japan).

19. PCTs were produced in the United States, France, Germany, Italy and Japan until the early 1980s, when all production is thought to have ceased. The cumulative world production is estimated to have been 60,000 tons between 1955 and 1980 (UNECE 2002).

(c) PBBs

20. Information on the production of PBBs is scarce. It is estimated that at least 11,000 tons of PBBs were produced worldwide, but production figures from some countries known to have produced PBBs are not available (IPCS 1994). PBBs were manufactured in the United States until 1979, in Germany until the mid-1980s, and in France until at least the mid-1990s. PBBs may still be in production in Asia (Lassen, Løkke and Andersen 1999).

21. The first PBB compound produced was hexabromobiphenyl, which was commercially known as FireMaster in the United States. FireMaster was produced from 1970 to 1974. Analysis has shown that FireMaster contained up to 80% hexa- and up to 25% heptabromobiphenyl. In France, a commercial mixture of PBBs was sold as Adine 0102. In Germany, highly brominated PBBs were produced and sold as Bromkal 80-9D. See annex I for examples of trade names and section IV.D for a discussion of trade names in inventory identification.

3. Use

(a) PCBs

22. PCBs were used in a very wide variety of industrial and consumer applications. The uses were categorized by the World Health Organization as completely closed, nominally closed and open ended (IPCS 1992). The uses included:

(a) Completely closed systems:

(i) Electrical transformers;

(ii) Electrical capacitors (including lamp ballasts);

(iii) Electrical switches, relays and other;

(iv) Electrical cables;

(v) Electric motors and magnets (very small amounts);

(b) Nominally closed systems:

(i) Hydraulic systems;

(ii) Heat transfer systems (heaters, heat exchangers);

(c) Open-ended systems:

(i) Plasticizer in polyvinyl chloride, neoprene, and other artificial rubbers;

(ii) Ingredient in paint and other coatings;

(iii) Ingredient in ink and carbonless copy paper;

(iv) Ingredient in adhesives;

(v) Pesticide extender;

(vi) Ingredient in lubricants, sealants and caulking material;

(vii) Fire retardant in fabrics, carpets, polyurethane foam, etc.;

(viii) Lubricants (microscope oils, brake linings, cutting oils, other lubricants).

23. While electrical transformers containing PCBs are defined as a “completely closed” application, industrial practices caused these PCBs to be transferred to other types of equipment, thus creating additional points of contact with the environment. A common practice was to top up or recharge non-PCB (mineral oil) transformers with PCBs when no other fluid was available.

24. PCB oils were also added to or disposed of with non-PCB fluids such as heating or cooling fluid, hydraulic fluid, brake fluid, engine oil and off-specification fuels. There are numerous anecdotal reports of employees in electrical utilities using PCB fluids to wash their hands and taking PCB fluids home for use in home heaters, hydraulic systems and motors (as a lubricant). Since most fluorescent lamp ballasts made before PCBs were banned contained PCBs, many homes and businesses that installed fluorescent lamps unknowingly acquired PCBs.

(b) PCTs

25. PCTs were used in almost exactly the same applications as PCBs but in much smaller amounts. Little is known, however, about remaining quantities because inventories have not been developed (UNECE 2002). It is known that very small amounts of PCTs were used in electrical equipment (Jensen and Jørgensen, 1983).

(c) PBBs

26. The principal use of PBBs was as a fire retardant. PBBs were added to acrylonitrile butadiene styrene (ABS) plastic (10% PBBs), coatings, lacquers and polyurethane foam (IPCS 1994;).

4. Wastes

27. Wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs are found in a number of physical forms, including:

(a) Equipment containing or contaminated with PCBs or PCTs (capacitors, circuit breakers, electrical cables, electric motors, electromagnets, heat transfer equipment, hydraulic equipment, switches, transformers, vacuum pumps, voltage regulators);

(b) Solvents contaminated with PCBs or PCTs;

(c) End-of-life vehicles and shredder light fraction (fluff) containing or contaminated with PCBs;

(d) Demolition wastes containing or contaminated with PCBs (painted materials, resin-based floorings, sealants, sealed glazing units);

(e) Oils consisting of, containing or contaminated with PCBs or PCTs (dielectric fluids, heat transfer fluids, hydraulic fluids, motor oil);

(f) Electrical cables isolated by polymers containing or contaminated with PCBs or PBBs;

(g) Soils and sediments, rock and aggregates (e.g. excavated bedrock, gravel, rubble) contaminated with PCBs, PCTs or PBBs;

(h) Sludge contaminated with PCBs, PCTs or PBBs;

(i) Plastics containing or contaminated with PBBs and equipment containing such materials;

(j) Fire suppression equipment containing or contaminated with PBBs;

(k) Containers contaminated through the storage of waste consisting of, containing or contaminated with PCBs, PCTs or PBBs.

28. Note that the categories above mainly apply to PCBs, which were produced in much larger quantities than PBBs or PCTs and have been stored as wastes awaiting disposal. PBBs and PCTs are rarely found in large bulk situations and therefore do not have the potential to form large amounts of waste.

II. Relevant provisions of the Basel and Stockholm Conventions

A. Basel Convention

29. Article 1 ("Scope of Convention") outlines the waste types subject to the Basel Convention. Article 1 paragraph 1(a) of the Basel Convention contains a two-step process for determining if a "waste" is a "hazardous waste" subject to the Convention. First, the waste must belong to any category contained in Annex I to the Convention ("Categories of Wastes to be Controlled"). Second, the waste must possess at least one of the characteristics listed in Annex III to the Convention ("List of Hazardous Characteristics").

30. Annex I lists some of the wastes that may consist of, contain or be contaminated with PCBs, PCTs or PBBs. These include:

Y6	Wastes from the production, formulation and use of organic solvents
Y8	Waste mineral oils unfit for their originally intended use
Y9	Waste oils/water, hydrocarbons/water mixtures, emulsions
Y10	Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)
Y11	Waste tarry residues arising from refining, distillation and any pyrolytic treatment
Y12	Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish
Y13	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives
Y14	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known
Y18	Residues arising from industrial waste disposal operations
Y39	Phenols; phenol compounds including chlorophenol
Y41	Halogenated organic solvents
Y42	Organic solvents excluding halogenated solvents
Y45	Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

31. Wastes contained in Annex I are presumed to exhibit an Annex III hazardous characteristic – for example H11 "Toxic (Delayed or Chronic)"; H12 "Ecotoxic"; or H6.1 "Poisonous (Acute)" – unless, through "national tests", they can be shown to not exhibit the characteristics. National tests may be useful for a particular hazard characteristic in Annex III until such time as the hazardous characteristic is fully defined. Guidance papers for each Annex III hazardous characteristic are currently being developed under the Basel Convention.

32. List A of Annex VIII describes wastes that are "characterized as hazardous under article 1 paragraph 1(a)" although "Designation of a waste on Annex VIII does not preclude the use of Annex III (hazard characteristics) to demonstrate that a waste is not hazardous." List B of Annex IX lists wastes that will not be wastes covered by article 1 paragraph 1(a), unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic. In particular, the following Annex VIII wastes are applicable to PCBs, PCTs or PBBs:

A1180	Waste electrical and electronic assemblies or scrap[1] containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g. cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B [B1110])[2]
A3180	Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), polychlorinated terphenyl (PCT),

[1] This entry does not include scrap assemblies from electric power generation.

[2] PCBs are at a concentration level of 50 mg/kg or more.

polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more[3]

33. List A of Annex VIII includes a number of wastes or waste categories that have the potential to contain or be contaminated with PCBs, PCTs or PBBs, including:

A1090	Ashes from the incineration of insulated copper wire
A1100	Dusts and residues from gas cleaning systems of copper smelters
A2040	Waste gypsum arising from chemical industry processes, when containing Annex I constituents to the extent that it exhibits an Annex III hazardous characteristic (note the related entry on list B [B2080])
A2060	Coal-fired power plant fly ash containing Annex I substances in concentrations sufficient to exhibit Annex III characteristics (note the related entry on list B [B2050])
A3020	Waste mineral oils unfit for their originally intended use
A3040	Waste thermal (heat transfer) fluids
A3050	Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives, excluding such wastes specified on list B (note the related entry on list B [B4020])
A3070	Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges
A3120	Fluff – light fraction from shredding
A3150	Waste halogenated organic solvents
A3160	Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations
A4070	Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers and varnish, excluding any such waste specified on list B (note the related entry on list B [B4010])
A4100	Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B
A4130	Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics
A4140	Wastes consisting of or containing off-specification or outdated 4 chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics
A4150	Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on human health and/or the environment are not known
A4160	Spent activated carbon not included on list B (note the related entry on list B [B2060])

34. For further information please refer to section II.A of the General Technical Guidelines.

B. Stockholm Convention[5]

35. The Stockholm Convention differentiates between two categories of PCBs:

(a) Intentionally produced PCBs whose production and use are to be eliminated or disposed of in accordance with the provisions of Annex A;

(b) Unintentionally produced persistent organic pollutants (POPs) listed in Annex C, for which Parties are required to take specified measures to reduce total releases derived from anthropogenic sources "with the goal of their continuing minimization and, where feasible, ultimate elimination". Unintentionally produced PCBs will be addressed in technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with PCDDs and PCDFs.

[3] The 50 mg/kg level is considered to be an internationally practical level for all wastes. However, many individual countries have established lower regulatory levels (e.g. 20 mg/kg) for specific wastes.

[4] "Outdated" means unused within the period recommended by the manufacturer.

[5] This section does not apply to PCTs and PBBs.

36. Annex A, Part II ("Polychlorinated biphenyls") outlines specific requirements with respect to PCBs, as follows:

"(a) With regard to the elimination of the use of polychlorinated biphenyls in equipment (e.g., transformers, capacitors or other receptacles containing liquid stocks) by 2025, subject to review by the Conference of the Parties, take action in accordance with the following priorities:

(i) Make determined efforts to identify, label and remove from use equipment containing greater than 10 per cent polychlorinated biphenyls and volumes greater than 5 litres;

(ii) Make determined efforts to identify, label and remove from use equipment containing greater than 0.05 per cent polychlorinated biphenyls and volumes greater than 5 litres;

(iii) Endeavour to identify and remove from use equipment containing greater than 0.005 percent polychlorinated biphenyls and volumes greater than 0.05 litres;

(b) Consistent with the priorities in subparagraph (a), promote the following measures to reduce exposures and risk to control the use of polychlorinated biphenyls:

(i) Use only in intact and non-leaking equipment and only in areas where the risk from environmental release can be minimized and quickly remedied;

(ii) Do not use in equipment in areas associated with the production or processing of food or feed;

(iii) When used in populated areas, including schools and hospitals, take all reasonable measures to protect from electrical failure which could result in a fire, and regular inspection of equipment for leaks;

(c) Notwithstanding paragraph 2 of article 3, ensure that equipment containing polychlorinated biphenyls, as described in subparagraph (a), shall not be exported or imported except for the purpose of environmentally sound waste management;

(d) Except for maintenance and servicing operations, do not allow recovery for the purpose of reuse in other equipment of liquids with polychlorinated biphenyls content above 0.005 per cent;

(e) Make determined efforts designed to lead to environmentally sound waste management of liquids containing polychlorinated biphenyls and equipment contaminated with polychlorinated biphenyls having a polychlorinated biphenyls content above 0.005 per cent, in accordance with paragraph 1 of article 6, as soon as possible but no later than 2028, subject to review by the Conference of the Parties;

(f) In lieu of note (ii) in Part I of this Annex, endeavour to identify other articles containing more than 0.005 per cent polychlorinated biphenyls (e.g. cable-sheaths, cured caulk and painted objects) and manage them in accordance with paragraph 1 of article 6;

(g) Provide a report every five years on progress in eliminating polychlorinated biphenyls and submit it to the Conference of the Parties pursuant to Article 15".

37. For further information, please refer to section II.B of the *General Technical Guidelines*.

III. Issues under the Stockholm Convention to be addressed cooperatively with the Basel Convention[6]

A. Low POP content

38. The following provisional definition for low POP content should be applied for PCBs: 50 mg/kg[7] For further information, please refer to section III.A of the *General Technical Guidelines*.

B. Levels of destruction and irreversible transformation

39. Regarding provisional definition for levels of destruction and irreversible transformation, please refer to section III.A of the *General Technical Guidelines*.

C. Methods that constitute environmentally sound disposal

40. Section IV.G of the present report contains a description of methods that are considered to constitute environmentally sound disposal of wastes consisting of, containing or contaminated with PCBs.

IV. Guidance on environmentally sound management (ESM)

A. General considerations

1. Basel Convention

41. One of the main vehicles for the promotion of ESM is the preparation and dissemination of technical guidelines such as the present document and the *General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants*. For further information please refer to section 4.1.1 of the *General Technical Guidelines*.

42. Parties planning or reviewing a national ESM programme should consult, inter alia, the Basel Convention 2003 guidance document *Preparation of a National Environmentally Sound Plan for PCB and PCB-Contaminated Equipment: Training Manual* (UNEP 2003a).

2. Stockholm Convention

43. The term "environmentally sound management" is not defined in the Stockholm Convention. However, environmentally sound methods for disposal of wastes consisting of, containing or contaminated with PCBs is to be determined by the Conference of the Parties in cooperation with the appropriate bodies of the Basel Convention.

44. 44. Parties should consult the document Interim Guidance for Developing a National Implementation Plan for the Stockholm Convention (UNEP 2003b).

3. Organization for Economic Cooperation and Development

45. For information regarding the Organisation for Economic Cooperation and Development and ESM, refer to section IV.A.3 of the *General Technical Guidelines*.

B. Legislative and regulatory framework

46. Parties to the Basel and Stockholm Conventions should examine national controls, standards and procedures, including those pertaining to ESM of wastes consisting of, containing or contaminated with POPs, to ensure these are in line with Convention provisions and obligations.

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[6] This section does not apply to PCTs and PBBs.

[7] Total amount of PCBs

47. Elements of a regulatory framework applicable to PCBs, PCTs and PBBs could also include the following:

(a) Enabling environmental protection legislation (sets release limits and environmental quality criteria);

(b) Prohibitions on the manufacture, sale, import and export (for use) of PCBs, PCTs and PBBs;

(c) Phase-out dates for PCBs that remain in service, inventory or storage;

(d) Hazardous materials and waste transportation requirements;

(e) Specifications for containers, equipment, bulk containers and storage sites;

(f) Specification of acceptable analytical and sampling methods for PCBs, PCTs and PBBs;

(g) Requirements for waste management and disposal facilities;

(h) General requirement for public notification and review of proposed government regulations, policy, certificates of approval, licences, inventory information and national emissions data;

(i) Requirements for identification and remediation of contaminated sites;

(j) Requirements for health and safety of workers;

(k) Other potential legislative controls (waste prevention and minimization, inventory development, emergency response).

48. The timing of the phase-out of PCBs (and to a lesser extent PCTs and PBBs) will probably be the most critical legislative concern for most countries, given that most of them already have some form of legislative framework dealing with PCBs.

49. For further information please refer to section IV.B of the *General Technical Guidelines*.

C. Waste prevention and minimization

50. Both the Basel and Stockholm Conventions advocate waste prevention and minimization, while PCB compounds are targeted in the Stockholm Convention for complete phase-out. PCBs, PCTs and PBBs should be taken out of service and disposed of in an environmentally sound manner.

51. Quantities of waste containing these compounds should be minimized through isolation and source separation in order to prevent mixing and contamination of other waste streams. For example, PCBs in electrical equipment, painted materials, resin-based floorings, sealants and sealed glazing units can contaminate large amounts of demolition waste if not separated prior to demolition.

52. Mixing of wastes with a PCB content above a defined low POP content with another material solely for the purpose of generating a mixture with a POP content below the defined low POP content is not environmentally sound. However, mixing of materials prior to waste treatment may be necessary in order to optimize treatment efficiencies.

53. For further information, please refer to paragraph 6 and section IV.C of the *General Technical Guidelines*.

D. Identification and inventories

1. Identification

54. PCBs, PCTs and PBBs have historically been found in several locations, including:

(a) Electrical utilities: transformers, capacitors, switches, voltage regulators, circuit breakers, light ballasts and cables;

(b) Industrial facilities: transformers, capacitors, voltage regulators, circuit breakers, light ballasts, heat transfer fluids, hydraulic fluids and fire suppression systems;

(c) Railroad systems: transformers, capacitors, voltage regulators and circuit breakers;

(d) Underground mining operations: hydraulic fluids and earthing coils;

(e) Military installations: transformers, capacitors, voltage regulators, hydraulic fluids and fire suppression systems;

(f) Residential/commercial buildings: capacitors, circuit breakers, light ballasts and fire suppression systems; elastic joints and fillers, sealing glues; paints; concrete and plaster

(g) Research laboratories: vacuum pumps, light ballasts, capacitors and circuit breakers;

(h) Electronics manufacturing plants: vacuum pumps, light ballasts, capacitors and circuit breakers;

(i) Waste-water discharge facilities: vacuum pumps and well motors;

(j) Automotive service stations: reused oil.

55. It is important to note that even experienced technical persons may not be able to determine the nature of an effluent, substance, container or piece of equipment by its appearance or markings. PCB equipment, for example, was typically not labelled according to the type of dielectric fluid it contained. Experienced inspectors may be able to determine the original contents from other information on the nameplate by using guidance manuals such as *Guidelines for the Identification of PCB and Materials Containing PCB* (UNEP 1999) or by contacting the manufacturer.

56. When identifying PCBs, PCTs and PBBs, information on production, use and waste types outlined in section I.B of the present report may be useful.

57. For further information, please refer to section IV.D.1 of the *General Technical Guidelines*.

2. Inventories

58. Inventories are an important tool in identifying, quantifying and characterizing wastes. A national inventory may be used to:

(a) Establish a baseline quantity of products, articles and wastes consisting of, containing or contaminated with PCBs, PCTs and PBBs;

(b) Assist with regulatory inspections;

(c) Assist with the preparation of emergency response plans;

(d) Track process with respect to the minimization and phase-out of these chemicals, where applicable.

When developing an inventory, priority should be placed on the identification of wastes with a high POP concentration.

59. The development of a national inventory requires a long-term commitment by the national government, the cooperation of owners and manufacturers of PCBs, PCTs and PBBs, a sound administrative process for collecting information on an ongoing basis and a computerized database system for storage of information. In some cases, government regulations may be required to ensure that owners report their holdings and cooperate with government inspectors.

60. A complete inventory of all PCBs, PCTs and PBBs is impossible to compile, mainly because of dispersive uses of these chemicals (e.g., use in inks, plasticizers, paint, flame retardants in small components, and lubricants).

61. For further information, please refer to section IV.D.2 of the *General Technical Guidelines*.

E. Sampling, analysis and monitoring

1. Sampling

62. Sampling in this section refers to the taking of a sample of gas, liquid or solid for later analysis either in the field or in a laboratory.

63. The types of matrices that are sampled for analysis of PCBs, PCTs and PBBs are shown below.

(a) Liquids:

(i) Water (surface water, rainwater, groundwater, soil pore water, drinking water, industrial process water, effluent water, condensate);

(ii) Landfill leachate

(iii) Askarel (PCBs and PCTs) liquid from transformers or other equipment or in bulk storage;

(iv) Mineral oil from transformers contaminated with PCBs or in bulk storage;

(v) Waste motor oil and other waste oils, fuels and organic liquids;

(vi) Liquid fire suppressants and retardants (PBBs);

(vii) Biological liquids (blood, urine);

(viii) Liquids collected from spills or from free-product subsurface recovery systems at contaminated sites;

(b) Solids:

(i) Solid or semi-solid PCB, PCT or PBB products;

(ii) Containers or equipment (rinse or wipe sample);

(iii) Soil, sediment, rubble, compost;

(iv) Paint chips, pieces of caulking and sealant, plastic chips, pieces of wire and cable, automobile shredder fluff, ceramics, wood, mixed solid wastes;

(v) Tissues or fabric used in the collection of wipe samples;

(vii) Filter materials;

(viii) Solids extracted from a liquid or sludge (suspended solids, precipitates, coagulated solids, filtered material);

(ix) Solids from industrial or disposal processes (fly ash, bottom ash, slag, still bottoms, other residues);

(x) Ice, snow and other frozen materials;

(xi) Plant materials and food;

(xii) Biological solids (whole animals, tissues, faeces);

(c) Gases:

(i) Product or waste gases in containers;

(ii) Stack gases from industry and treatment processes;

(iii) Volatile emissions from products, wastes, processes and contaminated sites;

(iv) Soil and groundwater gases;

(v) Air (ambient, personal breathing, confined space);

(vii) Biological gases (exhaled air, gases released by organisms).

64. For further information, please refer to section IV.E.1 of the *General Technical Guidelines*.

2. Analysis

65. Analysis refers to the determination of the physical, chemical or biological properties of a material using documented, peer-reviewed and accepted laboratory methods.

66. Each country should identify, through guidelines or legislation, standard methods that are required to be used for PCBs, PCTs and PBBs and the situations in which the methods should be used.

67. The methods specified should cover all aspects of the analytical process for each type of sample that could be collected, as per the list of sample materials in paragraph 63 above.

68. In very general terms, the methods available for chemical analysis for PCBs (UNEP 1999) are the following:

(a) Test kits: In many cases, the use of chlorine-determining test kits is recommended for oils. If the result is negative, a PCB analysis is not necessary. If the result is positive, analysis as described below should be performed, or the waste may be regarded as waste containing or contaminated with PCBs;

(b) High performance liquid chromatography (HPLC) coupled to adequate detectors;

(c) Gas chromatography (GC) with either packed columns or capillary columns (HRGC) coupled to detectors like electron capture (ECD), or mass selective (MSD) or high resolution mass spectrometers (HRMS).

69. Accreditation and certification of laboratories and interlaboratory calibration studies are important aspects of a national analytical programme. All laboratories should be able to meet quality standards as set and tested by government and by an independent body such as the International Organization for Standardization or by an association of laboratories.

70. For further information, please refer to section IV.E.2 of the *General Technical Guidelines*.

3. Monitoring

71. Monitoring programs should be implemented for operations managing wastes consisting of, containing or contaminated with PCBs, PCTs and PBBs. For further information please refer to section 4.5.3 of the *General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants*.

F. Handling, collection, packaging, labelling, transportation and storage

72. Handling, collection, packaging, labelling, transportation and storage are critically important steps as the risk of a spill, leak or fire (for example in preparation for storage or disposal) is equal to or greater than that during the normal operation of the equipment. The *Basel Convention: Manual for Implementation* (UNEP 1995a), the *International Maritime Dangerous Goods Code* (IMO 2002), the International Air Transport Association *Dangerous Goods Code* and the United Nations *Transport of Dangerous Goods Code* should be consulted to determine specific requirements for transport and transboundary movement of hazardous wastes.

1. Handling

73. The main concerns when handling wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs are human exposure, accidental release to the environment and contamination of other waste streams with PCBs, PCTs or PCTs. Such wastes should be handled separately from other waste types in order to prevent contamination of these other waste streams. Recommended practices for this purpose include:

(a) Inspecting containers for leaks, holes, rust, high temperature;

(b) Handling wastes at temperatures below 25^{o}C, if possible, due to the increased volatility at higher temperatures;

(c) Ensuring that spill containment measures are adequate and would contain liquid wastes if spilled;

(d) Placing plastic sheeting or absorbent mats under containers before opening containers if the surface of the containment area is not coated with a smooth surface material (paint, urethane, epoxy);

(e) Removing the liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and Teflon or silicon tubing;

(f) Using dedicated pumps, tubing and drums, not used for any other purpose, to transfer liquid wastes;

(g) Cleaning up any spills with cloths, paper towels or absorbent;

(h) Triple rinsing of contaminated surfaces with a solvent such as kerosene to remove all of the residual PCBs, PCTs or PBBs;

(i) Treating all absorbents and solvent from triple rinsing, disposable protective clothing and plastic sheeting as wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs when appropriate.

74. Staff should be trained in the correct methods of handling hazardous wastes.

2. Collection

75. A significant part of the total national amount of PCBs, PCTs and PBBs may be held in small quantities by small business owners and homeowners (for example in PCB fluorescent light ballasts, other small electrical devices, heat exchangers and heaters containing PCB or PCT fluids, PBBs in fire suppression systems, small containers of pure products and small stockpiles). It is difficult for small-quantity owners to dispose of these materials. For example, the regulatory situation may require that they be a registered waste generator, logistical considerations may prevent or discourage pick-up (e.g. no industrial waste pick-up allowed or available in a residential neighbourhood), and costs may be prohibitive. National, regional or municipal governments should consider establishing collection stations for these small quantities so that each small-quantity owner does not have to make individual transport and disposal arrangements.

76. Collection and collection depots for wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs should be separate from those for all other wastes.

77. It is imperative that collection depots do not become long-term storage facilities for wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs. The risk of environmental and human health impairment is higher for a large amount of wastes, even if properly stored, than for small quantities scattered over a large area.

76.bis For further information, please refer to section IV.F.2 of the *General Technical Guidelines*.

3. Packaging

78. Wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs should be packaged prior to storage or transport. Liquid wastes should be placed inter alia in double-bung steel drums. Regulations governing transport often specify containers of a certain quality (e.g. 16-gauge steel coated inside with epoxy). Therefore, containers used for storage should meet transport requirements in anticipation that they may be transported in the future.

79. Large, drained equipment may be stored as is, or may be placed inside a large container (overpack drum) or heavy plastic wrap if leakage is a concern. Small pieces of equipment, whether drained or not, should be placed in drums with an absorbent material. Numerous small pieces of equipment may be placed in one drum, as long as an adequate amount of absorbent material is present in the drum. Loose absorbents may be purchased from safety suppliers. Sawdust, vermiculite or peat moss may also be used.

80. Drums and equipment may be placed on pallets for movement by forklift truck and for storage. Equipment and drums should be strapped to the pallets prior to movement.

81. For further information, please refer to section IV.F.3 of the *General Technical Guidelines*.

4. Labelling

82. All drums, containers and equipment containing or contaminated with PCBs, PCTs or PBBs should be clearly labelled with both a hazard warning label and a label that gives the details of the equipment or drum. The details include the contents of the drum or equipment (exact counts of equipment or volume of liquid), the type of waste, and the name and telephone number of the responsible person.

5. Transportation

83. Transportation of dangerous goods and wastes is regulated in most countries, and the transboundary movement of wastes is controlled in particular by the Basel Convention.

84. Companies transporting wastes within their own country should be certified as shippers of hazardous materials and wastes and their personnel should be qualified.

6. Storage

85. While many countries have adopted storage regulations or developed storage guidelines related to PCBs, most do not have specific storage regulations or guidance related to PCBs, PCTs and PBBs. However, it can be assumed that the storage procedures should be similar to PCBs since the properties and toxicity of PCTs and PBBs are similar. While recommended practice varies somewhat from country to country, there are many common elements to safe storage of these wastes.

86. For further information, please refer to section IV.F.6 of the *General Technical Guidelines*.

G. Environmentally sound disposal

1. Pretreatment

87. Regarding pretreatment, please refer to section IV.G.1 of the *General Technical Guidelines*. In relation to size reduction, cutting and milling of capacitors should be performed immediately before destruction in a dedicated facility.

2. Destruction and irreversible transformation methods

88. Regarding destruction and irreversible transformation methods, please refer to section IV.G.2 of the *General Technical Guidelines*.

3. Other disposal methods when destruction or irreversible transformation does not represent the environmentally preferable option

89. Regarding other disposal methods when destruction or irreversible transformation does not represent the environmentally preferable option, please refer to section IV.G.3 of the *General Technical Guidelines*.

4. Other disposal methods when the POP content is low

90. 285. Regarding other disposal methods when the POP content is low, please refer to section IV.G.4 of the *General Technical Guidelines*.

H. Remediation of contaminated sites

91. Poor handling and storage practices may lead to releases of PCBs at sites storing these chemicals, resulting in contamination of sites with high levels of PCBs, which may pose serious health concerns. For information on the identification and remediation of contaminated sites, please refer to section IV.H of the *General Technical Guidelines*.

I. Health and safety

92. A health and safety plan for an individual facility should be developed by a trained health and safety professional with experience in PCB, PBB and/or PCT management. In general there are three main ways to protect workers from chemical hazards (in order of preference):

(a) Keep the worker away from all possible sources of contamination;

(b) Control the contaminants so that the possibility of exposure is minimized;

(c) Protect the worker using personal protective equipment.

93. All health and safety plans should adhere to the above principles and recognize local or national labour standards. For further information please refer to section IV.I of the *General Technical Guidelines*.

1. High-volume, high-concentration or high-risk situations

94. High-volume, high-concentration or high-risk PCB, PCT or PBB situations may include:

(a) Electrical rooms with large or multiple PCB transformers;

(b) Handling for transport;

(c) Dedicated (large-volume) storage sites;

(d) Treatment and disposal areas;

(e) Sites contaminated with a high concentration of PCBs, PCTs or PBBs at or near the surface.

95. At a minimum, the following should be included in PCB, PCT or PBB health and safety plans for high-volume, high-concentration situations or high-risk situations:

(a) The health and safety plan (HASP) should be in writing, with a copy posted at each site;

(b) Each worker who is to have access to the site should read the HASP and sign that they have read and understood it;

(c) The HASP may be written to encompass all hazards at a site but should have a section or chapter specifically detailing procedures for PCBs, PCTs or PBBs;

(d) Workers should only be present at a site when necessary for the servicing or inspection of equipment or stored materials;

(e) Workers entering a site should have appropriate health and safety and operational training for chemical, physical and biological hazards;

(f) Health and safety training should be performed annually;

(g) PCBs, PCTs and PBBs should be routinely monitored for these contaminants in air;

(h) When appropriate, workers entering a site should wear appropriate respiratory protection and impermeable fabric should cover the entire body (i.e coveralls with hood, face shield, gloves and boot covers or a full body suit);

(i) Spill clean-up kits and personal decontamination materials should be present in all areas containing PCBs, PCTs or PBBs;

(j) Workers who are, or are expected to be, routinely entering sites or working with these substances should be medically monitored, including a baseline medical examination;

(k) Where PCBs, PCTs or PBBs are to be handled in an open system, or where it is reasonably expected that the protective clothing of a worker may contact PCBs, PCTs or PBBs, a contaminant reduction zone should be established where workers can be decontaminated and remove their protective equipment;

(l) The HASP and general work procedures should be reviewed at least annually and revised if necessary to enhance safety and health at the site.

2. Low-volume, low-concentration sites or low-risk situations

96. The recommended health and safety practices outlined in the previous section do not apply to sites that contain or are contaminated with PCBs, PCTs and/or PBBs in amounts or concentrations that are seen as acute or chronically hazardous to human health and the environment. Low-volume, low-concentration or low-risk situations may include:

(a) Electrical transformers or other equipment with low-level PCB-contaminated mineral oil;

(b) Properties that contain products or articles that contain or are contaminated with PCBs in small quantities or low concentrations (e.g. light ballasts containing PCBs in the fluorescent fixtures);

(c) Facilities that unintentionally generate and release PCBs, PCTs or PBBs in very low concentrations with respect to human exposure limits;

(d) Sites contaminated with a low concentration of PCBs, PCTs or PBBs or where the contamination cannot directly come into contact with workers (for example, contamination is underground or under water and is not being excavated).

97. Despite the low risk some health and safety measures should be taken to minimize exposure, including health and safety training of personnel who are likely to come into contact with PCBs, PCTs or PBBs.

J. Emergency response

98. Emergency response plans should be in place for PCBs, PBBs and PCTs that are in service, in storage, in transport and at a disposal site. Further information on emergency response plans can be found in section IV.J of the *General Technical Guidelines* or in *Preparation of a National Environmentally Sound Plan for PCB and PCB-Contaminated Equipment: Training Manual* (UNEP 2003a).

K. Public participation

99. Parties to the Basel or Stockholm Convention should have an open public participation process. For further information please refer to section IV.K of the *General Technical Guidelines*.

Annex I

Synonyms and trade names for PCBs, PCTs and PBBs

Chemical	Some synonyms and trade names[8]
PCBs	Abestol, Aceclor, Adkarel, ALC, Apirolio (Italy), Apirorlio, Areclor, Arochlor, Arochlors, Aroclor/Arochlor(s) (USA), Arubren, Asbestol (USA), Ask/Askarel/Askael, Auxol, Bakola, Biclor, Blacol (Germany), Biphenyl, Clophen (Germany), Cloresil, Chlophen, Chloretol, Chlorextol (USA), Chlorfin, Chlorinal/Chlorinol, Chlorinated biphenyl, Chlorinated diphenyl, Chlorobiphenyl, Chlorodiphenyl, Chlorofen (Poland), Chlorphen, Chorextol, Chorinol, Clophen/Clophenharz (Germany), Cloresil, Clorinal, Clorphen, Crophene (Germany), Decachlorodiphenyl, Delofet O-2, Delor (Slovakia), Delor/Del (Slovakia), Delorene, Delorit, Delotherm DK/DH (Slovakia), Diaclor (USA), Diarol, Dicolor, Diconal, Disconon, DK (Italy), Ducanol, Duconal, Duconol, Dykanol (USA), Dyknol, Educarel, EEC-18, Elaol (Germany), Electrophenyl, Elemex (USA), Elinol, Eucarel, Euracel, Fenchlor (Italy), Fenclor (Italy), Fenocloro, Gilotherm, Hexol, Hivar, Hydelor, Hydol, Hydrol, Hyrol, Hyvol (USA), Inclor, Inerteen (USA), Inertenn, Kanechlor (Japan), Kaneclor, Kennechlor (Japan) , Kenneclor, Leromoll, Magvar, MCS 1489, Montar, Monter, Nepoli, Nepolin, Niren, NoFlamol, No-Flamol (USA), Non-Flamol, Olex-sf-d, Orophene, Pheaoclor, Pheneclor, Phenochlor, Phenoclor (France), Plastivar, Polychlorinated diphenyl, Polychlorinated diphenyls, Polychlorobiphenyl, Polychlorodiphenyl, Prodelec, Pydraul, Pyraclor, Pyralene (France), Pyranol (USA), Pyroclor (USA), Pyrochlor, Pyronol, Safe-T-Kuhl, Saft-Kuhl, Saf-T-Kohl, Saf-T-Kuhl (USA), Santosol, Santotherm (Japan), Santothern, Santovac, Sat-T-America, Siclonyl, Solvol, Sorol, Soval, Sovol (USSR), Sovtol, Tarnol (Poland), Terphenychlore, Therminal, Therminol, Turbinol
PCTs	Aroclor (US), Clophen Harz (W), Cloresil (A,B,100), Electrophenyl T-50 and T60, Kanechlor KC-C (Japan), Leromoll, Phenoclor, Pydraul
PBBs	Adine 0102, BB-9, Berkflam B_{10}, Bromkal 80, Firemaster BP-6, Firemaster FF-1, Flammex B-10, hbb, hexabromobiphenyl, HFO 101, obb, BB-8

[8] The list of trade names is not intended to be exhaustive.

Annex II

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